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Research Article

Field Performance of Eight Commercial Date Palm Cultivars of Balochistan Grown under Agro-Climatic Conditions of District Khairpur, Pakistan

Najamuddin Solangi[1*], Nazir Ahmed Soomro[1], Mushtaque Ahmed Jatoi[1], Ghulam Sarwar Channa[3], Abdul Aziz Mirani[1], Adel Ahmed Abul-Soad[2], and Ghulam Sarwar Markhand[1]

[1]Date Palm Research Institute, Shah Abdul Latif University, Khairpur, Pakistan
[2]Horticulture Research Institute, Agricultural Research Center, Giza, Egypt
[3]Department of Botany, Shah Abdul Latif University, Khairpur, Pakistan

Abstract: Field performance of eight commercial date palm cultivars of Balochistan was carried out under agro-climatic conditions of district Khairpur, Pakistan. Five years old offshoots of different date palm cultivars brought from Turbat and Panjgoor, Balochistan, and were cultivated in the Research Orchard of Date Palm Research Institute, Shah Abdul Latif University, Khairpur. In this study, vegetative, flowering, bunch and fruit physical characteristics were studied after ten years of plantation in the field. Fruits of different cultivars were collected at three distinct fruit growth stages (kimri, khalal and rutab) for morphological characterization (fruit colour, fruit length, fruit diameter, fruit weight, seed length, seed diameter, seed weight). Results of vegetative characteristics revealed that higher leaf/frond length (187.3 cm), pinnae number (208.6) and spine number (26.6) was observed in cv. Begum Jangi. Flowering characteristics showed that highest number of spathes (14.3) and number of strings per spathe (88.6) were noted in cv. Begum Jangi. Highest bunch length (44.6 cm) and bunch weight (15.4 kg) was observed in cv. Muzawati. Highest fruit length (4.3 cm, 5.3 cm and 5.6 cm) was recorded in cv. Aab-e-dandan at kimri, khalal and rutab stages respectively. Highest fruit weight (22.5 g) was observed in cv. Muzawati at kimri stage, 23.3 g in cv. Shakri at khalal stage and 24.0 g in cv. Muzawati at rutab stage. Highest seed length (2.41 cm) was noted in cv. Gogna at kimri stage, 2.97 cm at khalal and 3.0 cm at rutab stages were observed in cv. Aab-e-dandan. Higher pulp/fruit ratio (PFR) (94.6%) was observed in cv. Muzawati at khalal stage, whereas at rutab stage higher pulp/fruit ratio (94.4%) was recorded in cv. Halini at edible rutab stage. Findings of the current study revealed that soil and climate of district Khairpur were suitable for the cultivation of exotic commercial date palm cultivars in the area.

Keywords: Cultivars, Orchard, Kimri, Pinnae, Spine, Muzawati, Climate, Cultivation.

1. INTRODUCTION

Date palm (*Phoenix dactylifera* L.) is horticulturally important fruit crops belongs to the family Arecaceae is diploid (2n = 36) and dioecious; cultivated in the tropical and sub-tropical areas of the world [1, 2]. Pakistan is ranked at 6th position in dates export and production [3, 4]. Generally, the date palm is propagated via naturally occurring offshoots and seeds; however, the date palm cannot be propagated through seeds due to heterozygosity, therefore, elite date cultivars are propagated via offshoots for the production of true-to-type fruits; whereas the seed propagated date palms always produce fruits of inferior quality, and mainly indistinguishable to the mother tree [5]. In Pakistan dates occupy third position after citrus and mango in production and cultivated area [6]. Khairpur in Sindh and Turbat and Panjgur in Balochistan are the major dates producing and exporting areas in Pakistan. Khairpur is called biodiversity centre of the date palm enriched with 300 commercial and non-commercial varieties [4]. Commercially important varieties grown in district Khairpur are Aseel, Dhakki, Dedhi, Otakin, Kurh, Gajar, Karbalain, Khurmo, Fasli and Kashuwari. Several studies

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* Corresponding Author: Najamuddin Solangi <najamsolangi@gmail.com>

were conducted in different countries on the field performance of different date palm varieties for the evaluation of fruit quality [7-11]. Dates are oblong, berry with fibrous endocarp and fleshy mesocarp which constitutes 85-90% weight of the total fruit [12, 13]. Major constituents of dates are vitamins, minerals, sugar and several other compounds used as traditional medicine [14, 15]. Growth of dates is based on five stages, i.e., hababouk and kimri are early growth stages characterized with green colour, non-edible, and contain high tannins; next to the kimri is the khalal stage during which a particular colour of the fruit (red or yellow) is appeared, depending on the variety type; after khalal is the rutab stage (half ripened fruit), and final stage is tamar (fruit fully ripened) either on the tree in dry date cultivars or dried under the sun after harvesting the late khalal stage dates [16, 17]. Several studies have been conducted on vegetative, flowering and fruit evaluation of date palm in different regions of the world [17, 18-23]. Markhand *et al*. [4] characterized 85 date palm varieties; the study was based on the fruit size, fruit shape, fruit colour, perianth colour and size, micropyle position, fruit type (soft, dry or semi-dry) and edible stage (khalal, rutab or tamar). Abul-Soad *et al*. [24] carried out field evaluation (vegetative, flowering and fruit characteristics) of three Saudi Arabian date palm cultivars (Ajwa, Safawi and Ruthana) cultivated in Khairpur, Pakistan. Commercially important cultivars of date palm in district Khairpur are Aseel, Dhakki, Otakin, Kurh, Dedhi and Kashuwari, and are threatened by pests (Red Palm Weevil) and diseases (sudden decline disease and diplodia). Climate of district Panjgur is warm in summer with a maximum 45 °C, the annual rainfall is 25 mm, and the soil is sandy loam [25]. The sandy loam soil and shortage of water reduces the yield of the dates per tree in Turbat and Panjgur. In district Khairpur, the soil is clay loam, and temperature ranges from 45 to 50 °C during the summer (June and July). Cultivation of commercially important exotic date palm cultivars in district Khairpur is need of the time, which will boost existing varietal structure of date palm in the area. This study was conducted on field performance of eight commercial date palm cultivars originally belong to Balochistan, Pakistan to introduce in the district Khairpur. The study will be helpful to the date palm farmers in propagating elite date cultivars of Balochistan, exhibiting better adaptability in the area, in addition to the existing cultivars. The objectives of the current study were also extended to check field performance of eight commercial date palm cultivars of Balochistan grown under agro-climatic conditions of district Khairpur, Pakistan.

2. MATERIALS AND METHODS

2.1. Vegetative Characteristics

Vegetative characteristics were based on: trunk circumference, leaf length (cm), pinnae number, pinnae length (cm), leaf width, pinnae width, spine number, spine length (cm), spine area length (cm), measured with a measuring tape [26].

2.2. Flower Characteristics

Flower characteristics were taken as: date of spathes emergence (first and last), date of spathes pollination (first and last), number of spathes per tree, spathe length, number of strings per spathe, length of strings.

2.3. Bunch Characteristics

Bunch characteristics were taken as: bunch number per tree, bunch length, number of strings per bunch, string length, number of fruits per string (kimri stage), number of fruits per string at harvest (late khalal stage), harvest date, bunch weight and yield per palm [26].

2.4. Fruit Physical Characteristics

Fruits were obtained from ten years old trees at different stages, i.e., kimri, khalal and rutab cultivated in Research Orchard of Date Palm Research Institute, Shah Abdul Latif University, Khairpur (latitude 27.490418˚ N, longitude 68.761593˚ E). Average annual rainfall of Khairpur is 87.6 mm (3.45 in.) and temperature is 50 ˚C during July. Fruit physical characteristics were taken at kimri, khalal and rutab as fruit length, fruit width, fruit weight, fruit/ pulp ratio, seed length, seed width, seed weight. Vernier Caliper was used to measure the length and diameter of fruits.

Pulp/fruit ratio (PFR) was recorded using the following formula:

$$PFR = \frac{PW}{FW} \times 100$$

Seed weight (SW) was calculated using the following formula:

$$SW = FW - PW$$

FW and *PW* are fruit weight and pulp weight respectively [26].

2.5. Data Analysis

Data collection was based on selection of three replicates for each treatment regarding vegetative, flower and bunch characteristics, whereas, ten randomly picked fruits were selected for each fruit growth stage for data analysis. The data were analyzed as two-way-ANOVA followed by LSD (≤ 0.05) as described by Steel *et al*. [27].

3. RESULTS

3.1. Vegetative Characteristics

In this study, data were obtained with two-way-ANOVA, exhibited the significant effect of cultivar (0.002), treatment (0.000) and combined effect of cultivar and treatment (0.000). Data presented in Table 1 show that higher tree circumference (192 cm) was noted in cv. Aab-e-dandan; whereas, lowest tree circumference (103 cm) was observed in cv. Gogna. Highest leaf/frond length (380.7 cm) was noted in cv. Begum Jangi; whereas, lowest leaf/frond length (264.5 cm) was recorded in cv. Halini. Number of pinnae (208.6) was higher in cv. Begum Jangi and lowest pinnae number (151.6) was found in cv. Halini. Highest pinnae length (41.39 cm) was noted in cv. Muzawati; whereas, lowest pinnae length (30.0 cm) was found in cv. Pashna. Higher leaf width (80.6 cm) was observed in cv. Aab-e-dandan and lowest leaf width (55 cm) was noted in cv. Pashna. Highest pinnae width (2.70 cm) was observed in cv. Kooznabad and lowest pinnae width (1.8 cm) was recorded in cv. Aab-e-dandan. Number of spines (26.6) was higher in cv. Begum Jangi and lower number of spines (17.0) was noted in cv. Pashna. Highest spine length (13.33 cm) was observed in cv. Aab-e-dandan and lowest spine length (8.40 cm) was observed in cv. Halini. Spine area length was significantly higher in cv. Gogna (107.3 cm), and lower in cv. Halini (52.1 cm).

3.2. Flowering Characteristics

Data presented in Table 2 show that first spathe emergence was noted in cv. Shakri on 11th February; whereas, in cv. Halini first spathe emergence was observed on 12th March. Earlier pollination was carried out in cv. Aab-e-dandan on 20th February, and late pollination was done in cv. Halini on 21st March. Last spathe emergence was found in cv. Aab-e-dandan on 23rd February and in cv. Halini last spathe emergence was noted on 21st March. Last spathe pollination was carried out earlier in cv. Shakri on 27th February, and in cv. Halini pollination was done on 29th March. Highest number of spathes (15) was recorded in cv. Aab-e-dandan; whereas, lowest number of spathes (11.67) was observed in cv. Shakri. Highest length of spathe (76.77 cm) was noted in cv. Halini and lowest spathe length (48.66 cm) was observed in cv. Muzawati. Significantly highest number of spikelets per spathe (88.66) was recorded in cv. Begum Jangi and lowest number

Table 1. Vegetative characteristics of different date palm cultivars of Balochistan grown in district Khairpur, Pakistan.

Cultivars	Trunk circumference (cm)	Leaf length (cm)	Pinnae number	Pinnae length (cm)	Leaf width (cm)	Pinnae width (cm)	Spine number	Spine length (cm)	Spine area length (cm)
Aab-e-dandan	192 ± 0.5^{a}	342.3 ± 1.1^{d}	194 ± 0.5^{b}	40.2 ± 1.3^{b}	80.6 ± 0.4^{a}	1.8 ± 0.5^{c}	19 ± 1.1^{bc}	13.3 ± 0.5^{a}	77 ± 1.2^{ab}
Begum Jangi	187.3 ± 1.1^{b}	380.7 ± 0.8^{a}	208.6 ± 1.2^{a}	36.2 ± 1.2^{d}	78.5 ± 1.3^{b}	2.0 ± 0.6^{bc}	26.6 ± 1.3^{a}	11.4 ± 1.5^{bc}	101.3 ± 1.5^{b}
Gogna	103 ± 0.72^{g}	293.3 ± 1.2^{f}	181.3 ± 0.6^{bc}	34 ± 0.8^{de}	64.0 ± 0.4^{e}	2.5 ± 1.3^{ab}	25.0 ± 0.6^{b}	11.6 ± 1.5^{bc}	107.3 ± 0.6^{a}
Halini	161.6 ± 0.6^{e}	264.5 ± 0.6^{d}	151.6 ± 0.7^{d}	31.4 ± 0.5^{e}	67.5 ± 0.6^{bc}	2.4 ± 1.2^{bc}	18 ± 0.5^{de}	8.4 ± 0.6^{d}	52.1 ± 1.2^{b}
Kooznabad	185.1 ± 0.7^{c}	328.3 ± 0.5^{b}	177.6 ± 0.6^{d}	38.8 ± 1.5^{c}	71.9 ± 0.2^{bc}	2.70 ± 1.3^{a}	20 ± 1.5^{d}	9.8 ± 0.7^{bc}	81.0 ± 1.5^{c}
Muzawati	176 ± 1.2^{d}	353.4 ± 1.3^{c}	179.6 ± 1.2^{c}	41.3 ± 2.2^{a}	78.3 ± 1.2^{b}	2.6 ± 1.4^{ab}	21.6 ± 0.4^{c}	11.9 ± 0.6^{bc}	71.6 ± 1.5^{d}
Pashna	160.3 ± 0.7^{e}	330.3 ± 0.7^{c}	180.6 ± 0.5^{bc}	30 ± 0.7^{ef}	55 ± 0.8^{d}	2.0 ± 0.5^{b}	17.0 ± 1.1^{e}	12.0 ± 0.5^{b}	83.3 ± 0.5^{c}
Shakri	158.6 ± 0.3^{f}	341.3 ± 1.2^{d}	196.6 ± 0.4^{b}	38.9 ± 0.4^{c}	71.6 ± 1.5^{bc}	1.8 ± 1.4^{d}	25.3 ± 1.4^{b}	10.8 ± 1.3^{c}	104.6 ± 0.5^{b}
LSD (0.05)	0.000**	0.000**	0.000**	0.000**	0.000**	0.02**	0.000**	0.05*	0.000**

Variability: Cultivar = 0.002, Treatment = 0.000, CV x Treatment = 0.000.
Values followed by the same letter are not significantly different at $p < 0.05$.

Table 2. Flowering characteristics of different date palm cultivars of Balochistan grown in district Khairpur, Pakistan.

Cultivars	Date of 1st spathes emergence	Date of 1st spathes pollination	Date of Last spathes emergence	Date of last spathes pollination	Number of spathes	Spathes length (cm)	Number of spikelets per spathes	spikelet length (cm)
Aab-e-dandan	14-02-2012	20-02-2012	23-02-2012	03-03-2012	11.0 ± 0.8^{c}	66.5 ± 0.5^{b}	43.6 ± 1.1^{cd}	41.3 ± 1.2^{b}
Begum Jangi	02-03-2012	08-03-2012	11-03-2012	17-03-2012	14.3 ± 0.5^{a}	62.7±1.2^{c}	88.6±0.6^{a}	43.1±0.4^{a}
Gogna	17-02-2012	24-02-2012	25-02-2012	04-03-2012	13.0 ± 1.5^{b}	51.6 ± 0.5^{d}	47.2 ± 1.1^{c}	27.1 ± 1.4^{de}
Halini	12-03-2012	21-03-2012	21-03-2012	29-03-2012	10.3 ± 1.5^{d}	76.7 ± 0.5^{a}	34.6 ± 1.4^{d}	26.5 ± 1.3^{e}
Kooznabad	20-02-2012	27-02-2012	02-03-2012	08-03-2012	12.0 ± 1.5^{c}	62.3 ± 1.6^{c}	30.8 ± 1.3^{e}	28.8 ± 0.5^{de}
Muzawati	06-03-2012	13-03-2012	15-03-2012	23-03-2012	13.0 ± 1.6^{b}	48.6 ± 0.5^{f}	53.2 ± 0.6^{b}	30.1 ± 0.6^{d}
Pashna	26-02-2012	05-03-2012	07-03-2012	15-03-2012	11.6 ± 0.6^{c}	52.5 ± 0.8^{e}	21.3 ± 1.8^{f}	20.9 ± 1.5^{de}
Shakri	11-02-2012	21-02-2012	20-02-2012	27-02-2012	10.6 ± 1.5^{d}	55.3 ± 1.6^{e}	51.8 ± 0.6^{b}	35.6 ± 0.4^{c}
LSD (0.05)					0.005**	0.000**	0.000**	0.000**

Variability: Cultivar = 0.006, Treatment = 0.002, CV x Treatment = 0.000.
Values followed by the same letter are not significantly different at $p < 0.05$.

of spikelets (21.33) was noted in cv. Pashna. Significantly highest length of spikelets (43.11 cm) was observed in cv. Begum Jangi and lowest length of spikelets (20.55 cm) was recorded in cv. Halini.

3.3. Bunch Characteristics

Data presented in Table 3 show that highest bunch number (av. 14.3) was observed in cv. Begum Jangi followed by cv. Muzawati (av. 13.0) and Gogna (av. 13.0); whereas, lowest bunch number (av. 10.6) was observed in cv. Shakri followed by cv. Halini (av. 10.3). Highest bunch length (44.6 cm) was recorded in cv. Muzawati followed by Begum Jangi (43.0 cm) and Shakri (43.0 cm); whereas, lowest bunch length (38.8 cm) was noted in cv. Aab-e-dandan. Number of strands per bunch (65) were higher in cv. Begum Jangi followed by cv. Muzawati (51.5) and cv. Shakri (51.7); whereas, lowest number of strings (36.5) was found in cv. Halini. Highest strand length (42.4 cm) was noted in cv. Aab-e-dandan, and lowest strand length (33.1 cm) was observed in cv. Pashna. Significantly highest number of fruits per strand (35.7) was recorded in cv. Muzawati followed by cv. Pashna (31.7); whereas, lowest number of fruits per strand (27.8) was noted in cv. Aab-e-dandan. Significantly higher number of fruits per strand at harvest time (26.2) was observed in cv. Pashna, and lowest number of fruits per strand at harvest time (21.8) was observed in cv. Aab-e-dandan. Earlier harvest was done in cv. Aab-e-dandan on 3rd July; whereas, late harvest was done in cv. Halini on 17th September. Highest bunch weight (15.4 kg) was found in cv. Muzawati followed by cv. Pashna (13.6 kg); whereas, lowest bunch weight (10.7 kg) was noted in cv. Aab-e-dandan. Significantly higher total yield per tree (150.3 kg) was observed in cv. Muzawati; whereas, lowest yield per tree (97 kg) was noted in cv. Shakri.

3.4. Fruit Physical Characteristics at Different Fruit Growth Stages (kimri, khalal and rutab)

Data presented in Table 4 show fruit physical characteristics recorded at three different growth stages (kimri, khalal, and rutab). Fruits of Aab-e-dandan (Figure (1a)), Begum Jangi (Figure (1b)), Gogna (Figure (1c)), Halini (Figure (1d)), Kooznabad (Figure (1e)), Muzawati (Figure (1f)), Pashna (Figure (1g)) and Shakri (Figure (1h)) were green at kimri stage, and remained inedible due to occurrence of high amount of tannins. The fruits of Aab-e-dandan (Figure (2a)), Begum Jangi (Figure (2b)), Gogna (Figure (2c)), Halini (Figure (2d)), Kooznabad (Figure (2e)), Muzawati (Figure (2f)), Pashna (Figure (2g)) and Shakri (Figure (2h)) at khalal stage acquired a particular colour and sweet taste. The fruits of Aab-e-dandan (Figure (3a)), Begum Jangi (Figure (3b)), Gogna (Figure (3c)), Halini (Figure (3d)), Kooznabad (Figure (3e)), Muzawati (Figure (3f)), Pashna (Figure (3g)) and Shakri (Figure (3h)) also acquire sweet taste due to increase in sugar content at rutab stage; whereas, half of the fruit remain yellow or red reflecting the particular fruit colour. Results presented in Table 4 indicate that highest fruit length (4.33, 5.30 and 5.63 cm) at kimri, khalal and rutab stages respectively was noted in cv. Aab-e-dandan, and lowest fruit length (2.7 cm in cv. Halini at kimri stage, 4.3 cm

Table 3. Bunch characteristics of different date palm cultivars of Balochistan grown in district Khairpur, Pakistan.

Cultivars	Number of bunches	Bunch length (cm)	Strands per bunch	Strand length (cm)	Total fruits per strand	Total fruits/ strand at harvest	Bunch weight (kg)	Total yield (kg/Palm)	Date of harvest
Aab-e-dandan	11.0 ± 0.7^{c}	38.8 ± 1.1^{e}	43.1 ± 0.7^{c}	42.4 ± 0.6^{a}	27.8 ± 0.8^{e}	21.8 ± 0.4^{e}	10.7 ± 0.6^{e}	100 ± 0.7^{e}	03-07-2012
Begum Jangi	14.3 ± 1.2^{a}	43.0 ± 1.3^{b}	65.0 ± 0.3^{a}	36.3 ± 0.7^{c}	29.2 ± 0.5^{d}	24.1 ± 1.4^{b}	12.7 ± 1.5^{c}	137 ± 0.5^{b}	11-09-2012
Gogna	13.0 ± 0.5^{b}	40.3 ± 1.5^{c}	41.6 ± 1.4^{c}	34.8 ± 1.3^{d}	28.7 ± 1.4^{d}	22.5 ± 0.5^{b}	11.7 ± 1.2^{d}	120 ± 1.3^{d}	07-07-2012
Halini	10.3 ± 0.6^{d}	39.6 ± 0.5^{d}	36.5 ± 1.3^{d}	35.5 ± 0.5^{e}	30.0 ± 1.5^{c}	23.8 ± 1.3^{d}	12.3 ± 1.6^{c}	99.1 ± 1.2^{f}	17-09-2012
Kooznabad	12.0 ± 0.7^{c}	42.5 ± 0.6^{c}	37.5 ± 1.2^{d}	36.8 ± 1.3^{c}	31.3 ± 1.3^{b}	23.2 ± 1.5^{c}	11.4 ± 0.6^{d}	120.8 ± 0.7^{d}	17-08-2012
Muzawati	13.0 ± 0.8^{b}	44.6 ± 0.8^{a}	51.5 ± 0.6^{b}	39.2 ± 0.4^{b}	35.7 ± 1.4^{a}	25.2 ± 1.6^{b}	15.4 ± 0.5^{a}	150.3 ± 0.5^{a}	14-09-2012
Pashna	11.6 ± 0.6^{c}	41.0 ± 0.7^{c}	37.3 ± 0.7^{c}	33.1 ± 1.2^{f}	31.7 ± 1.1^{b}	26.2 ± 0.7^{a}	13.6 ± 0.4^{b}	130 ± 1.5^{c}	14-08-2012
Shakri	10.6 ± 0.7^{d}	43.0 ± 0.8^{b}	51.7 ± 1.2^{b}	36.9 ± 1.3^{c}	29.8 ± 1.5^{c}	22.3 ± 1.5^{e}	11.2 ± 0.5^{d}	97.0 ± 1.5^{f}	06-07-2012
LSD (0.05)	0.000**	0.000**	0.000**	0.000**	0.000**	0.001**	0.003**	0.000**	

Variability: Cultivar = 0.004, Treatment = 0.001, CV x Treatment = 0.000.
Values followed by the same letter are not significantly different at $p < 0.05$.

and 4.8 cm in cv. Kooznabad at khalal and rutab stages respectively) was observed. Significantly highest fruit width (2.5 cm in cv. Shakri at kimri stage, 2.90 cm in cv. Halini at khalal stage and 3.1 cm in cv. Halini at rutab stage) was observed; whereas, lowest fruit width (2.0 cm) was recorded in cv. Begum Jangi at kimri stage, 2.12 cm in cv. Pashna at khalal stage, 2.6 cm in cv. Gogna at rutab stage. Highest fruit weight (22.5 g) was noted in cv. Muzawati, 23.3 g in cv. Shakri at khalal stage and 23.7 g in cv. Shakri at rutab stage; whereas, lowest fruit weight (9.8 g, 11.3 g and 11.9 g) was observed in cv. Begum Jangi at kimri, khalal and rutab stages respectively. Highest seed length (2.7 cm was noted in cv. Shakri at kimri stage), 2.8 cm in cv. Pashna at khalal stage and 2.9 cm in cv. Pashna at rutab stage; whereas, lowest seed length (2.0 cm) was recorded in cv. Muzawati at kimri stage, 2.17 cm in cv. Halini at khalal stage and 2.4 cm in cv. Halini at rutab stage. Seed weight (2.0 g, 2.4 g and 2.6 g) was higher in cv. Shakri at kimri, khalal and rutab stages respectively; whereas, lowest seed weight (1.0 g) was noted in cultivars Begum Jangi and Halini at kimri stage, 1.1 g was observed in cv. Kooznabad at khalal stage and 1.50 g was noted in cv. Muzawati at rutab stage. Highest seed width (0.9 cm) was found in cv. Gogna at kimri stage, 0.9 cm in cv. Aab-e-dandan at khalal stage and 1.20 cm in cv. Pashna at rutab stage; whereas, lowest seed width (0.56 cm) was observed in cv. Aab-e-dandan at kimri stage, 0.8 cm in cv. Kooznabad at khalal stage and 0.9 cm in cv. Kooznabad at rutab stage. Significantly highest flesh weight (21.6 g, 22.0 g and 22.5 g) was noted in cv. Muzawati at kimri, khalal and rutab

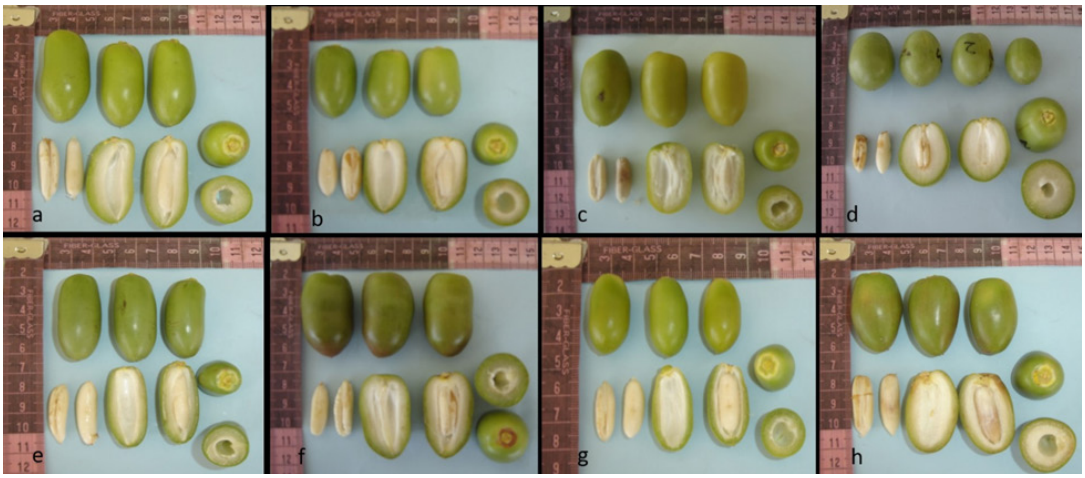

Fig. 1. Fruit of different date varieties at kimri stage, (a) Aab-e-dandan, (b) Begum Jangi, (c) Gogna, (d) Halini, (e) Kooznabad, (f) Muzawati, (g) Pashna, (h) Shakri.

Fig. 2. Fruit of different date varieties at khalal stage, (a) Aab-e-dandan, (b) Begum Jangi, (c) Gogna, (d) Halini, (e) Kooznabad, (f) Muzawati, (g) Pashna, (h) Shakri.

Fig. 3. Fruit of different date varieties at Rutab stage, (a) Aab-e-dandan, (b) Begum Jangi, (c) Gogna, (d) Halini, (e) Kooznabad, (f) Muzawati, (g) Pashna, (h) Shakri.

stages respectively; whereas, lowest flesh weight (8.8 g, 9.5 g and 9.9 g) was recorded in cv. Begum Jangi at kimri, khalal and rutab stages respectively. Higher pulp fruit ratio (94.9%) was noted in cv. Halini at kimri stage followed by cv. Aab-e-dandan (92.2%); whereas, higher pulp fruit ratio (94.6%) was observed in cv. Muzawati at khalal stage followed by cv. Halini (91.4%). Significantly highest pulp fruit ratio (95.4%) was observed in cv. Halini at rutab stage followed by cv. Muzawati (93.7%). Lowest pulp fruit ratio (89.0%) was observed in Pashna at kimri stage followed by cv. Begum Jangi (89.8%). Whereas, significantly lower pulp fruit ratio (84.4% and 83.5%) was recorded in the fruits of cv. Begum Jangi at khalal and rutab stages of respectively.

4. DISCUSSION

Vij *et al*. [19] conducted study on different date palm cultivars (Hillawi, Shamran, Khadrawi, Deglet Noor, Medjool, Barhee, Zahidi, Dayri, Khalasa, Hayani, Thoory and Itima) regarding vegetative, flowering and fruit physical characteristics. El-Alwani and El-Ammari [28] studied morphological characteristics (trunk diameter, leaf length, width of leaf base, blade length, spine area length, spine number, pinnae length, pinnae width and pinnae number). Different studies [29-37] observed the variations in growth parameters in different date palm cultivars, cultivated under different environmental conditions, i.e., fruit setting, yield, fruit physical and chemical characteristics. Aslam *et al*. [38] conducted study on physio-chemical properties of dates grown in Turbat, Balochistan; the data was recorded in cultivar Begum Jangi, i.e., fruit length (3.1 cm), fruit weight (6.87 g), fruit width (1.9 cm), seed length (1.8 cm) and seed weight (0.7 g). Similarly, the data were recorded in cultivar Halini, i.e., fruit length (2.9 cm), fruit

Table 4. Fruit physical characteristics of different date palm cultivars at kimri, khalal and rutab stages.

Growth Stage	Cultivars	Fruit Length (cm)	Fruit Width (cm)	Fruit Weight (gm)	Seed Length (cm)	Seed Weight (gm)	Seed Width (cm)	Flesh Weight (gm)	Pulp Fruit Ratio (%)
Kimri	Aab-e-dandan	4.3 ± 1.2^{a}	2.2 ± 1.1^{bc}	13.8 ± 0.8^{c}	2.2 ± 0.5^{b}	1.0 ± 1.6^{c}	0.5 ± 0.5^{bc}	12.8 ± 0.5c	92.2 ± 1.4^{b}
	Begum Jangi	3.5 ± 0.6^{abc}	2.0 ± 1.2^{bc}	9.8 ± 0.4^{c}	2.1 ± 0.6^{b}	1.0 ± 1.4^{b}	0.6 ± 0.6^{c}	8.8 ± 0.6^{d}	89.8 ± 1.3^{d}
	Gogna	3.6 ± 1.3^{ab}	2.3 ± 1.4^{bc}	15.1 ± 1.2^{c}	2.4 ± 0.3^{b}	1.3 ± 1.2^{b}	0.9 ± 1.1^{a}	13.8 ± 0.4^{c}	91.3 ± 1.5^{c}
	Halini	2.7 ± 0.7^{c}	2.4 ± 0.5^{b}	19.7 ± 0.6^{b}	1.9 ± 0.4^{c}	1.0 ± 0.5^{c}	0.7 ± 1.4^{b}	18.7 ± 1.3^{b}	94.9 ± 0.7^{b}
	Kooznabad	3.5 ± 0.5^{abc}	2.2 ± 0.6^{bc}	10.2 ± 0.6^{d}	2.2 ± 0.4^{b}	0.9 ± 0.7^{d}	0.7 ± 0.5^{b}	9.3 ± 0.6^{d}	90.5 ± 0.5^{c}
	Muzawati	3.3 ± 0.4^{bc}	2.2 ± 0.4^{bc}	22.5 ± 1.2^{a}	2.0 ± 0.5^{d}	0.9 ± 1.5^{d}	0.6 ± 1.2^{c}	21.6 ± 1.5^{a}	95.9 ± 1.5^{a}
	Pashna	3.2 ± 0.5^{bc}	1.9 ± 1.1^{c}	13.7 ± 0.5^{c}	2.3 ± 1.2^{b}	1.5 ± 0.5^{ab}	0.6 ± 1.4^{c}	12.2 ± 1.3^{c}	89.0 ± 1.5^{d}
	Shakri	4.01 ± 0.6^{b}	2.5 ± 0.6^{a}	21.6 ± 0.4^{b}	2.7 ± 0.7^{a}	2.0 ± 0.3^{a}	0.8 ± 0.6^{b}	19.6 ± 1.5^{b}	90.7 ± 0.6^{c}
	LSD (0.05)	**0.03****	**0.05****	**0.000*****	**0.002****	**0.07^{ns}**	**0.08^{ns}**	**0.000****	**0.042***
Khalal	Aab-e-dandan	5.3 ± 0.5^{a}	2.3 ± 0.8^{c}	14.6 ± 0.4^{bc}	2.9 ± 0.6^{a}	1.34 ± 0.6^{d}	0.9 ± 1.4^{b}	13.2 ± 1.7^{d}	90.8 ± 0.9^{c}
	Begum Jangi	4.6 ± 0.4^{b}	2.4 ± 1.3^{c}	11.3 ± 0.6^{d}	2.2 ± 1.7^{cd}	1.7 ± 0.5^{b}	0.8 ± 1.2^{b}	9.5 ± 0.9^{e}	84.4 ± 0.3^{d}
	Gogna	4.9 ± 0.6^{b}	2.4 ± 1.5^{c}	15.9 ± 1.3^{c}	2.5 ± 1.4^{bc}	1.5 ± 0.7^{c}	1.0 ± 1.5^{a}	14.3 ± 0.5^{d}	90.3 ± 0.5^{c}
	Halini	4.4 ± 0.5^{b}	2.9 ± 1.4^{b}	21.6 ± 0.5^{b}	2.1 ± 1.7^{d}	1.8 ± 1.3^{b}	0.9 ± 0.7^{c}	19.8 ± 0.3^{c}	91.4 ± 0.8^{b}
	Kooznabad	4.3 ± 1.5^{c}	2.4 ± 0.8^{c}	11.8 ± 0.4^{bc}	2.5 ± 1.5^{c}	1.1 ± 0.6^{d}	0.8 ± 0.6^{d}	10.6 ± 0.6^{f}	89.9 ± 0.7^{c}
	Muzawati	5.0 ± 1.2^{ab}	2.7 ± 0.5^{c}	23.3 ± 1.2^{a}	2.6 ± 0.6^{c}	1.2 ± 0.8^{c}	0.9 ± 0.3^{c}	22.0 ± 0.4^{a}	94.6 ± 0.6^{a}
	Pashna	4.3 ± 0.7^{c}	2.1 ± 0.8^{d}	14.9 ± 1.5^{bc}	2.8 ± 1.5^{b}	1.8 ± 1.1^{b}	0.9 ± 0.3^{c}	13.0 ± 1.1^{d}	86.8 ± 0.5^{d}
	Shakri	4.8 ± 1.3^{b}	2.4 ± 0.5^{a}	23.3 ± 0.7^{a}	2.8 ± 0.6^{b}	2.4 ± 1.5^{a}	1.0 ± 0.6^{b}	20.8 ± 1.4^{b}	89.3 ± 0.4^{c}
	LSD (0.05)	**0.004****	**0.07****	**0.000****	**0.005****	**0.06^{ns}**	**0.07^{ns}**	**0.000****	**0.051***
Rutab	Aab-e-dandan	5.6 ± 1.4^{a}	2.7 ± 0.8^{c}	15.5 ± 0.6^{d}	3.0 ± 0.8^{a}	1.9 ± 0.6^{bc}	1.0 ± 0.3^{c}	13.5 ± 0.5^{c}	87.4 ± 0.6^{c}
	Begum Jangi	4.8 ± 0.6^{d}	2.7 ± 0.5^{c}	11.9 ± 0.6^{f}	2.6 ± 1.1^{cd}	1.9 ± 0.8^{b}	0.9 ± 0.8^{d}	9.9 ± 0.6^{f}	83.5 ± 0.4^{e}
	Gogna	5.1 ± 1.5^{ab}	2.6 ± 0.6^{d}	16.7 ± 0.7^{c}	2.7 ± 1.5^{c}	1.8 ± 0.7^{c}	1.1 ± 0.5^{b}	14.8 ± 0.8^{d}	89.0 ± 1.5^{c}
	Halini	4.8 ± 0.6^{d}	3.1 ± 0.4^{a}	22.1 ± 0.6^{b}	2.4 ± 0.9^{d}	1.9 ± 0.8^{b}	1.0 ± 0.4^{b}	20.1 ± 1.1^{c}	95.4 ± 0.8^{a}
	Kooznabad	4.8 ± 1.5^{d}	2.8 ± 1.4^{c}	12.9 ± 1.3^{e}	2.7 ± 0.8^{c}	1.7 ± 1.5^{c}	0.9 ± 0.6^{c}	11.1 ± 1.5^{f}	86.5 ± 0.5^{c}
	Muzawati	5.5 ± 1.3^{b}	2.9 ± 0.6^{b}	24.0 ± 1.5^{a}	2.8 ± 1.5^{bc}	1.5 ± 1.6^{d}	1.0 ± 0.4^{b}	22.5 ± 1.1^{a}	93.7 ± 0.4^{b}
	Pashna	4.9 ± 0.5^{c}	2.8 ± 0.5^{b}	15.5 ± 0.5^{d}	2.9 ± 0.4^{b}	1.9 ± 0.8^{b}	1.2 ± 0.5^{a}	13.5 ± 1.2^{c}	87.4 ± 0.7^{d}
	Shakri	5.1 ± 0.5^{c}	2.8 ± 0.7^{b}	23.7 ± 1.3^{b}	2.9 ± 1.5^{b}	2.6 ± 0.4^{a}	1.1 ± 0.3^{b}	21.0 ± 0.5^{b}	88.9 ± 0.8^{c}
	LSD (0.05)	**0.006****	**0.05****	**0.000****	**0.05****	**0.08^{ns}**	**0.06^{ns}**	**0.000****	**0.041***

Values followed by the same letter are not significantly different at $p < 0.05$.

weight (8.57 g), fruit width (1.3 cm), seed length (1.8 cm) and seed weight (0.54 g). Further, the data recorded in cultivar Pashna, i.e., fruit length (2.8 cm), fruit weight (4 g), fruit width (1.5 cm), seed length (1.9 cm) and seed weight (0.64 g). On the contrary, the fruit length (4.8 cm) and fruit weight (11.9 g) was observed in cultivar Begum Jangi, whereas fruit length (4.8 cm) and fruit weight (22.1 g) was observed in cultivar Halini in district Khairpur at rutab stage. Dates at rutab stage contain high moisture content compared to tamar stage. Generally, the dates grown in district Khairpur showed excellent fruit size and weight in all studied cultivars of Balochistan. Soil of district Khairpur is different to the soil of Turbat and Panjgur, Balochistan. Sandy loam soil of these areas and water shortage reduces the bunch number and yield per tree in Turbat and Panjgur. In the present study such growth parameters were studied showed differences among different cultivars regarding vegetative, flowering and fruit physical characteristics, but simultaneously all growth parameters were normal and did not show any type abnormal growth. Morphological attributes of tree and fruits showed that soil (clay loam) and climatic conditions of district Khairpur

(Shah Abdul Latif University, Khairpur) were suitable for the growth of exotic date palm cultivars brought from Balochistan, Pakistan cultivated in district Khairpur, Pakistan. Temperature in district Khairpur fluctuate from 40 ℃ (during May) to 50-52 ℃ (June to July), which is acceptable range for growth and ripening of date palm fruit from kimri to rutab stage. Soil of Turbat and Panjgur is sandy loam and average temperature is 45-50 ℃ during July. Plants show variation in yield, vegetative traits and morphological properties of fruits and seeds in response to environmental changes [39, 40]. El-Sharabasy and Sherif [20] conducted field evaluation of three dry date palm cultivars (Sakkoti, Bertamoda and Gondila) regarding vegetative, fruit physical and chemical characteristics. Bacha *et al*. [41] studied fruit physical and chemical characteristics of four date palm cultivars (Seleg, Sakhi, Khudari and Nebut Seif) during three stages of fruit development (kimri, khalal and tamar). In the current study fruit physical characters were studied at three distinct fruit growth stages (kimri, khalal and rutab). Solangi *et al*. [17] conducted study on the physico-chemical attributes of three Saudi Arabian cultivars of the date palm i.e., Ajwa, Safawi and Ruthana, and observed that soil and climate of district Khairpur, Pakistan was suitable for the cultivation. Quality of the fruits is important character to obtain a maximum economic profit and create a better relationship between demand and supply. Kimri is the second fruit growth stage after hababouk (longest period of the fruit growth) characterized as green, inedible, and exhibits rapid growth. Al Udhaib [42] recorded the fruit length (27.5 mm) and fruit weight (5.8 g) at kimri stage. Weekly growth (90% at kimri stage) decreased to 20% at late kimri stage was observed by Tafti and Fooladi [43]. Abdul-Hamid *et al*. [44] and Solangi *et al*. [17] observed differences in fruit dimensions and length in cv. Ajwa i.e., fruit diameter (14.6 mm) and fruit length (26.4 mm).. Khodabakhshian and Khojastehpour [45] recorded fruit measurements at kimri stage such as, length, width and thickness (34.4, 17.5, and 16.80 mm, respectively). Similarly, the current study described the fruit measurements from kimri (Figure 1) to rutab stage (Figure 3), showed differences in fruit colour, size and weight. After kimri stage, fruit gradually convert to edible khalal stage (third fruit growth stage), and is characterized with the development of a particular colour of the fruits (red or yellow) depending on the type of variety (Figure 2). Late khalal stage is the last fruit growth stage before conversion of fruits into rutab, and is characterized with highest fruit weight, length and dimension. Several studies [17, 46-47] observed that after kimri stage, fruit converts to the next stage, the khalal, which brings a change in the fruit colour i.e., green to yellow or red depend on the variety, with increase in fruit length and width, decrease in weekly growth and increase in sugars. Al-Jasass *et al*. [48] described different colours in Moroccan dates at khalal. Biglari *et al*. [49] stated that change in the colour of dates was generally due to genetic differences develop particular colour pigments at khalal stage. Different pigments (carotenoid, chlorophyll and anthocyanin) produce green, yellow and red colours in dates from kimri to khalal stage [50]. In the current study, colour of all fruits was green at kimri stage, whereas the colour of the fruits at khalal stage was red (Shakri and Muzawati) and yellow (Aab-e-dandan, Begum Jangi, Gogna, Halini, Kooznabad and Pashna). Fruit dimensions of the dates were higher at khalal stage [51]. Studies conducted on dates in Tunisia [52], Iran [53] and Pakistan [17, 24] reported higher fruit dimensions at khalal. Similarly in the present study higher fruit dimensions were noted at khalal stage. Edible rutab stage is obtained before harvesting during which the khalal stage dates convert into edible rutab stage, whereas, dates remain attached in the bunches on the tree. Half of the date fruit turn into soft brown or black from one side with development of sweet taste due to high concentration of sugar and is called rutab [17, 42] (Figure 3). Al-Shahib and Marshall [47] described that after harvest storage of khalal dates under low temperature can save from spoilage. Ahmed *et al*. [54] suggested that proper fruit harvest stage is rutab, which saves the fruit from ripening failure, however, fruit harvesting at early khalal stage consume more time in drying process. Khalal stage, dates contain high moisture content, therefore fruit contain more weight as compared to tamar stage dates which contain low weight due to significant decrease in moisture content [17, 55]. The size of date fruit reduces at rutab and tamar stage compared to kimri and khalal stages of fruit growth [45]. Tafti and Fooladi [43] observed difference in weight of the fruit at ripening stage in cv. Shamsaei. The current study described size of fruits increases rapidly from kimri to khalal, while decrease from rutab to tamar due to decrease in the moisture content.

5. CONCLUSIONS

Field evaluation of eight date palm cultivars of Balochistan exhibited normal vegetative, bunch and fruit morphology. Variations were observed among different cultivars regarding vegetative, flowering and fruit physical characteristics were cultivar dependent, but fruit size of all studied cultivars was excellent. Pollination time varies among different studied cultivars did not affect the quality of fruits. Highest yield was noted in cv. Muzawati at harvest time. Evaluation of fruit physical characteristics showed significant variations among fruits of different cultivars at different growth stages regarding colour, size and weight. Cultivar Aab-e-dandan showed higher fruit size at different growth stages. The obtained results may not comparable to the dates obtained from their original place, i.e., Turbat and Panjgur, Balochistan due to variation in climate and soil and water availability. The results obtained in the present study will support the selection of elite commercial date palm cultivars to cultivate and streamline the varietal structure of the date palm in the area.

6. CONFLICT OF INTEREST

Authors declare that they have no any conflict of interest.

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